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DEPARTMENT OF HORTICULTURE

THE FERTILIZATION OF PEACH ORCHARDS

Potash and Acid Phosphate

Potash, Acid Phosphate and Nitrate of Soda.

BY
W. H. ALDERMAN

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FERTILIZATION OF PEACH ORCHARDS

W. H. ALDERMAN

Introduction

Upon no other phase of agricultural experiment station work has there been so much energy expended and so little definite information accumulated as upon the subject of fertilizers. So many unknown factors with assumed values enter into the problem that the final clearing of the equation and the solving of the value of x leaves the investigator troubled and harassed by doubt as to the accuracy of his own mathematics. In fact the solution of one unknown only opens the way for a study of the next.

The difficulties attending the study of the food requirements of a plant are enormous and our methods of overcoming them are as yet only crude and unsatisfactory. The soil with its infinite variety of mechanical structures and chemical compositions offers the first obstacle. The chemist, the physicist. and the bacteriologist make their painstaking analyses and yet we dare not accept their results as an index to the **plant producing** power of the soil or as a final means of comparison with other soils. The close inter-relation between plant growth and soil moisture, soil temperature, soil bacteria, and the amount and solubility of plant food constituents make such a basis of comparison impossible. If we add to the problem the varying requirements of different kinds of plants and of different varieties of the same kind, we at once lead the investigator into a labyrinth as puzzling in its windings as the maze of ancient Crete—and slender is the modern skein of thread that leads to light.

The agronomist has made some little progress in solving his fertilizer problems but the horticulturist is barely started. The problems of the latter are more difficult than those of the former and progress must necessarily be slower. The slow development of a tree, its long period of preparation for a crop, its tendency to biennial cropping and the difficulty

of establishing satisfactory standards for measuring and comparing results necessarily retard progress.

There is at present a regrettable lack of trustworthy data upon the influence of fertilizers upon peaches. The apple, because of its greater importance and more general cultivation has been the subject of considerable study but the experiment stations that have published any but the most meager data regarding peaches, may be counted upon the fingers of one hand. With a full realization of his own limitations and deeply appreciating the incompleteness of his work, the author ventures to submit this preliminary report in the hope that it may be of some service to the rapidly increasing number of peach growers in West Virginia and to his co-workers in other states, who are studying the same problem.

PREVIOUS WORK.

As before indicated, but very little systematic work has been done in the study of the food requisites of the peach. The problem so far has been attacked along two lines. The first was an attempt to determine by careful chemical analysis of plant and fruit the amount and proportion of the several elements in the tree and to deduce from this data the probable kinds and amounts of plant food required. Other investigators have adopted the simple and more certain method of applying different fertilizers to the trees and watching results.

In the way of analytical work, New Jersey* has probably made the most valuable contribution. In 1896 a one-year-old peach tree (Crawford Late) was planted and each year the prunings, fruit and leaves were gathered and analyzed. The tenth year (1905) the whole tree was carefully dug and analysis made. Table I shows the total amounts of plant food removed by the various parts of the tree during the ten-year period.

The most notable feature of the analysis is the large amount of nitrogen and the comparatively small amount of phosphoric acid used. It is noteworthy that the total weight

*New Jersey Sta. An. Rept. 1906—Page 192-203.

TABLE I. *Plant Food Removed by New Jersey Peach Tree in Ten Years.*

Part of Tree	Weight	Nitrogen (N)	Phosphoric Acid P_2O_5	Potash K_2O
Wood and roots	319.2 lbs	0.846 lbs	0.286 lbs	0.442 lbs
Leaves	170.5	1.775	0.351	0.991
Fruit	128.3	0.225	0.121	0.258
Total	615.0	2.855	0.758	1.691
Amount plant food removed per acre (173 trees)		490 lbs Equivalent to Nitrate of Soda 3062 lbs	131 lbs Equivalent to 16% Acid Phosphate 812 lbs	293 lbs Equivalent to Muriate of Potash 586 lbs

of leaves produced exceeded that of the fruit by over 42 pounds,* and that the leaves are very rich in nitrogen.

In comparison with the New Jersey results it is interesting to note those secured by the New York Experiment Station at Geneva. In this case all the foliage, fruit and new growth were weighed and analyzed from three mature peach trees—Elberta ten years old, Chili and Champion seven years old. While by this method the new growth in the roots and the enlargement in diameter of the trunk and limbs could not be considered, the analyses throw interesting light on the plant food removed by a tree in a single season. The New York trees were much larger and more vigorous than the New Jersey tree, as is evidenced by the fact that the average yield from each of the three trees for one year is greater than the total yield for six bearing years of the New Jersey tree. This is also borne out by the fact that the New York trees averaged 45.7 lbs. of leaves, while the greatest amount produced in any one year by the New Jersey tree after it came into bearing was 35.3 lbs. and in one year it produced only a little over nine pounds.

The New York analyses agree with those from New Jersey in that they show nitrogen to be the most important element of plant food entering into the makeup of the tree. Next and nearly equaling nitrogen comes potash, while phos-

*For some reason the yield from this tree was light, the average yield for the orchard being 277 pounds. If the yield of this tree had been up to the average the plant food used by it would have been increased to nitrogen 3.106 pounds, phosphoric acid .898 pounds and potash 1.99 pounds.

Table II. *Plant Food Removed by New York Peach Tree in One Year*†

	Weight	Nitrogen Lbs.	Phosphoric Acid Lbs.	Potash Lbs.
Fruit and pulp....................	165.04	.120	.064	.297
Stones	9.96	.026	.008	.007
Leaves	45.75	.420	.067	.274
New Wood	12.83	.055	.013	.028
Total	233.58	.621	.152	.606

phoric acid is little needed. The larger amounts of plant foods removed by the New York trees are due to their larger size and greater activity. When it is considered that it required 173 trees to fill an acre in New Jersey and 120 in New York, it will be seen that the difference in total plant food removed per acre in the experiment in question will not vary widely. Table III shows the amount removed in each case per year when in full bearing.

Table III. *Plant Food Removed Per Acre Per Year*

	Nitrogen	Phosphoric Acid	Potash
New Jersey (173 trees).........................	64 lbs	18 lbs	40 lbs
New York (120 trees)	75	18	72
Average	69.5	18	56
Equivalent Amounts	Nitrate of Soda 463	16% Acid Phos. 112.5	Mur. of Potash. 112.

That the New Jersey and New York analyses are accurate is indicated by the work of Winton and Ogden† of the Connecticut Station, who found from analysis of the fruit alone that a peach crop of 390 baskets per acre (three baskets per tree from 130 trees) would remove from the soil each season 19.7 lbs. of nitrogen, 4.2 lbs. of phosphoric acid and 21.9 lbs. of potash. This checks up with the other tests in that small amounts of phosphoric acid and large amounts of the nitrogen and potash were used.

It is evident from the foregoing that the peach is a heavy feeder. In fact Van Slyke, Taylor and Andrews‡ found that the peach made greater inroads into the soil's

*Adapted from Van Slyde, Taylor and Andrews, Agr'l. Exj. Sta. Geneva, N. Y., Bul. 265.
†Winton and Ogden, Conn. Agr'l. Expt. Sta. Ann. Rep. 1895—Page 157.
‡Van Slyke, Taylor and Andrews, Agr'l. Exp't. Sta.—Geneva, N. Y.—Bul. 265.

resources than any other fruit. Nearly all soils in West Virginia contain relatively large amounts of potash but are deficient in phosphoric acid and nitrogen. As the peach feeds mainly upon nitrogen and potash it seems reasonable to suppose that the addition of nitrogen alone would be all that is necessary, assuming that the potash and the rather insignificant phosphoric acid requirements of the tree would not overtax the supply already in the soil. This would seem even more plausible if we accept as a fact the theory that nitrate of soda in breaking up sets free or makes available no inconsiderable quantity of potash.

The work of Wheeler* and others of the Rhode Island Station offers evidence further supporting the hypothesis that if nitrate of soda is used the application of potash will be unnecessary. He found that "benefit from soda seemed to have resulted in certain cases, which could not be readily explained upon the assumption that it was due to a greater liberation of potash." It is thought the beneficial effects of soda are due in part, at least, to its ability to satisfy certain needs in a plant which would otherwise have been satisfied with potash. Thus the available supply of potash in the soil would be conserved and more of it could be used in the actual manufacture of plant tissue. Wheeler further states, "It appeared that though possibly unable to wholly replace potash * * * * sodium may and often does perform some part of one or more of the important functions of potassium, and thus increases the amount of dry matter which the plant can produce."

Plat Tests of Fertilizers.—The chief value of the analytical methods discussed in the preceding paragraphs lies in their suggestions for further work in field testing of fertilizer influence, or to aid in explaining the behavior of field tests. Some of the earliest work with peaches was undertaken in New Jersey, where in 1884 a twelve-plat experiment was started and records kept for a period of ten years.† The results of this work were so contradictory that only conclusions of a general nature were published. Inter-

*Wheeler, H. J.—Manures & Fertilizers—Page 348-359—New York, 1913.
†New Jersey Agr'l. Exp't. Sta. An. Rep. 1894—Page 121.

feeding of plats and serious damage to the trees by storms harassed the investigators and finally compelled them to abandon the test. Nitrate of soda used alone yielded less than the check, whereas barnyard manure applied at the rate of twenty loads per year out-yielded all other plats. Potash and phosphates made appreciable gains when used alone but gave much better returns when in combination with nitrate of soda. The most valuable feature of these results is in their indication of the fallacy of the time-honored belief that large applications of nitrogen, and particularly manure, will be disastrous to peach orchards.

The same year, 1894,* this station reported upon another experiment which had been in progress for a shorter period. In this test excessive quantities of complete fertilizers were applied, 3,060 lbs. per acre in one instance, but only one crop yield is recorded and about the only conclusion to be reached is that it is nearly impossible to overfeed a peach tree.

Connecticut Experiments.—From 1896 to 1904, inclusive, the Connecticut Station maintained a peach fertilizer experiment near Branford. No check plats were maintained and leguminous cover-crops were grown over part of the plats, so that it is exceedingly difficult to ascertain what were the determining factors. The arrangement of the plats and the results secured are shown in Table IV.

*New Jersey Agr'l. Exp't. Sta. An. Rep. 1894—Page 126.

Table IV. *A Nine Year Peach Fertilizer Experiment in Connecticut*‡

Plats	Fertilizer Used	Average Yield Per Tree Per Year
A	Muriate of Potash and Acid Phosphate	2.7 baskets
B	Muriate of Potash, Acid Phosphate and Cottonseed Meal	3.2 baskets
C	Muriate of Potash and Acid Phosphate (same as Plat A) and Crimson Clover Cover Crop	2.6 baskets
D	Muriate of Potash doubled and Acid Phosphate and Crimson Clover Cover Crop	3.1 baskets
E	Muriate of Potash quadrupled and Acid Phosphate and Crimson Clover Cover Crop	3.7 baskets
F	Sulphate of Potash quadrupled and Acid Phosphate and Crimson Clover Cover Crop	3.6 baskets

It will be observed that the addition of nitrogen in the form of cottonseed meal raised the production of Plat B .5 of a basket and that by increasing the application of potash in combination with nitrogen-gathering cover-crops the yield was correspondingly increased. It is difficult to say whether the increased yields of plats D, E, and F are due to the heavy applications of potash or to the nitrogen collected and made available by the cover crop. From Close's† work in Delaware we find that a good cover crop of crimson clover contains nitrogen equivalent to 840 lbs. of nitrate of soda. No inconsiderable amount of this nitrogen is derived from the air, so it may be readily observed that these plats were receiving a liberal application of nitrogen together with the increased potash.

In the spring of 1903 nitrate of soda at the rate of 250 lbs. per acre was applied to plats E and F. The effect was so beneficial that the following year the entire six plats were given a treatment of nitrate of soda at the rate of 350 lbs. per acre. Jenkins explained that, "the favorable effect of nitrate of soda sown the year before on plats E and F was so very evident, in the more vigorous growth and better looking wood that in addition to other fertilizers, 700 lbs. of nitrate of soda was applied evenly over the whole piece." Following this, the experiment was of course abandoned and no attempt was made to interpret the results.

A survey of the foregoing can lead to but one conclusion,—practically nothing definite is known about the plant food requirements of the peach.

The following contribution to our present scanty store of knowledge on the subject contains some rather clear cut features that tend to cast the shadow of doubt over a few preconceived notions that have been current in horticultural literature.

*Adapted from Jenkins, E. H. Conn. Agr'l. Exp't. Sta. An. Rept. 1904—Page 444.
†Close, C. P. Delaware Bul. 61—1903.

WEST VIRGINIA EXPERIMENTS.

Three experiments are recorded in this report. The first did not come under the observation of the writer and the results are taken from data which has come to his hand through the courtesy of Professor L. C. Corbett, now in charge of the horticultural work in the United States Department of Agriculture, Washington, D. C. The second and third experiments have been under the direct charge of the present horticulturist and his associates for the past three years. In collecting data an attempt was made to observe and measure all effects of the various treatments upon both tree and fruit. The observations are recorded whenever possible in actual weights, measurements or counts, so that the results may be not only more clearly understood, but of greater value to other investigators working upon the same or similar problems.

The Experiment at Paw Paw.

In the spring of 1899, L. C. Corbett, then Horticulturist of the West Virginia Agricultural Experiment Station, began an elaborate fertilizer experiment upon peaches in the Miller orchards at Paw Paw. No less than thirty-eight plats were treated with the following materials in varying amounts, singly and in combination; nitrate of soda, muriate of potash, sulphate of potash, dissolved bone, bone meal, slag, acid phosphate, and wood ashes. The experiment was continued six years but unfortunately only fragmentary and rather scattered data concerning the results are available. A brief summary of the records is hereby presented in the hope that, taken in connection with more recent work, certain salient facts concerning the requirements of the peach tree may be presented with more force. No records of actual yields are available but notes upon the vigor, growth, foliage, color and maturity of fruit were taken in 1901, 1902, and 1904.

A survey of the records for the three years shows that the best plats were three that had received complete fertilizers with formulae as follows: 2-5-7, 2-3-12 and 1-7-9. A fourth plat to which a complete fertilizer running 5-7-9 was applied was inferior to the first three. No explanation of this can

be given since the addition of nitrogen in all other cases resulted in increased vigor. The amounts applied per tree in each case were 2 lbs. the first year, 4 lbs. the second, 5 lbs. the third, 6 lbs. the fourth, and 8 lbs. the fifth and sixth years.

The various materials when used singly or in incomplete combinations showed some striking results.

Nitrate of Soda.—This carrier of nitrogen when used alone gave the best results of all the incomplete fertilizers. In all cases the use of nitrogen was correlated with increased vigor, luxuriant foliage, greater productiveness and greener color of fruit.

Muriate of Potash.—When used alone at the rate of one pound to the tree this material tended to check growth and leaf formation slightly, but when increased to two pounds the toxic effects were plainly visible, and two and one-half pounds killed the trees. When used in combination with nitrate of soda the evil effects were somewhat ameliorated but when combined with slag they were, if anything, more pronounced.

Sulphate of Potash.—This form of potash was not fatal to the trees unless applied in quantities of five pounds or more per tree but in no case did it add to the vigor of the plant when smaller quantities were used. When applied to trees in new ground its injury was less apparent, due possibly to the counteracting presence of nitrates in this soil. High color of fruit was associated with the use of both muriate and sulphate of potash but it seems probable that this is due to the lack of heavy foliage and the weakened condition of the tree. This point will be discussed later in connection with more recent experiments.

Wood Ashes.—Applications of four and eight pounds per tree adversely affected the condition of the foliage but otherwise caused no change.

Slag.—The application of slag resulted in a slightly impaired vigor of foliage and a correspondingly higher color of fruit.

Acid Phosphate.—Applications of from two to five pounds per tree failed to affect the development of either fruit, foliage or wood.

Dissolved Bone.—When applied at the rate of five pounds per tree some slight benefits were apparently derived but smaller applications were of no avail.

Bone Meal.—Same as dissolved bone.

The foregoing conclusions are based upon rather incomplete data and should be accepted tentatively until reinforced or discountenanced by other work.

Sleepy Creek Experiment.

In the spring of 1911, A. L. Dacy, now Associate Horticulturist in charge of vegetable gardening, began an orchard fertilization experiment on the property of the Sleepy Creek Orchard Company, of which Mr. S. H. Fulton is manager. The orchard, which is situated about two miles from Sleepy Creek, Morgan County, is upon rolling land characteristic of the non-mountainous portion of that region.

At the time the experiment was laid off the orchard was beginning its seventh year and had produced three profitable crops. The method of handling up until that time had been that usually practiced by successful peach growers of the Eastern Panhandle. The first year an intercrop of tomatoes was grown, the second and third years cowpeas were used as cover crops and since then rye and clover have been used, but the clover never succeeded. Beginning with the fifth year commercial fertilizer analyzing 3-8-10 was applied at the rate of 500 pounds per acre each year. The orchard was tilled each season and received the usual dormant and summer sprays for scale, curculio, brown rot, and scab.

Plan of the Experiment.—A block of trees as nearly uniform in growth as could be found was selected in one section of the 200-acre peach and apple orchard. Nine plats were laid out, each consisting of a single row containing nine Waddell and eleven Carman* trees. The plant foods applied were carried in nitrate of soda, acid phosphate and muriate of potash, which were applied to the various plats as indicated in Table V.

The fertilizers have been applied each year on the following dates:—May 19, 1911; May 22, 1912; May 26, 1913,

*Twelve Edgemont trees were originally included in each plat but yellows, borers and other troubles destroyed so many of them that this variety was finally discarded.

TABLE V. *Arrangement of Plats at Sleepy Creek*

PLAT 1—Nitrate of Soda	1½ lbs.	per tree	(200 lbs. per acre)
Acid Phosphate 16%	2½ lbs.	per tree	(335 lbs. per acre)
PLAT 2—Nitrate of Soda	1½ lbs.	per tree	(200 lbs. per acre)
Muriate of Potash	1 lb.	per tree	(135 lbs. per acre)
PLAT 3—Nitrate of Soda	1½ lbs.	per tree	(200 lbs. per acre)
Acid Phosphate 16%	2½ lbs.	per tree	(335 lbs. per acre)
Muriate of Potash	1 lb.	per tree	(135 lbs. per acre)
PLAT 4—Check			
PLAT 5—Acid Phosphate 16%	2½ lbs.	per tree	(335 lbs. per acre)
Muriate of Potash	1 lb.	per tree	(135 lbs. per acre)
PLAT 6—Nitrate of Soda	1½ lbs.	per tree	(200 lbs. per acre)
Acid Phosphate 16%	2½ lbs.	per tree	(335 lbs. per acre)
Muriate of Potash	1 lb.	per tree	(135 lbs. per acre)
PLAT 7—Nitrate of Soda	1½ lbs.	per tree	(200 lbs. per acre)
Acid Phosphate 16%	2½ lbs.	per tree	(335 lbs. per acre)
Muriate of Potash	2 lbs.	per tree	(270 lbs. per acre)
PLAT 8—Nitrate of Soda	1½ lbs.	per tree	(200 lbs. per acre)
Acid Phosphate 16%	2½ lbs.	per tree	(335 lbs. per acre)
Muriate of Potash	3 lbs.	per tree	(395 lbs. per acre)
PLAT 9—Caustic Lime	7½ lbs.	per tree	(1000 lbs. per acre)
(Applied every third year)			

and May 19, 1914. The application of each material was made by hand in measured amounts for each tree and was spread evenly over the ground covered by the spread of the branches. The plats are separated by a guard row of alternate apple and peach trees to prevent cross feeding. In taking the records the end trees of each plat have been discarded to eliminate possible sources of error which might come from these trees getting plant food from outside the fertilizer block.

Since the experiment was started the orchard has been cultivated each year until early in July when a cover crop has been sown. Fortunately for the fertilizer test no leguminous crop has been grown, the seed which was sown one year failing to germinate. As a matter of fact the non-leguminous covers which have been produced have been very light and the humus content of the soil is consequently low.

Soil Type.—The soil is a thin red shale loam, a type widely distributed over the counties of the Eastern Panhandle and upon which a great many peach and apple orchards are located. The analyses in Table VI, taken from samples collected in 1913, indicate a soil low in all the elements of fertility and appreciably acid. The analyses were made by Prof. B. H. Hite, station chemist, in accordance

with the official method* of the American Association of Agricultural Chemists. Although three applications of the fertilizers had been made to the plats, no perceptible changes were brought about in the composition of the soil. In the lime plat the CaO content is apparently increased and the acidity of the subsoil strikingly diminished, although only one application of 1,000 pounds per acre had been made, three years previous.

Table VI. *Analyses Sleepy Creek Soils*

Top Soil 0-6 in... Sub-soil 6-12 in.

Plat	Soil	Moisture	P_2O_5	N.	K_2O	CaO	Humus	Acidity (CaO lbs. per acre)
1	Top soil	2.53	.08	.058	.13	.05	1.15	1240
	Sub-soil	4.85	.08	0.44	.19	.05	0.86	2540
2	Top soil	2.81	.10	.052	.06	.06	1.50	1340
	Sub-soil	5.54	.11	.034	.08	.06	1.07	3300
3	Top soil	2.30	.09	.049	.33	.10	1	1320
	Sub-soil	2.59	.10	.041	.12	.07	1.06	3920
4	Top soil	1.05	.09	.056	.32	.10	1	1500
	Sub-soil	6.30	.07	.041	.22	.05	0.95	2720
5	Top soil	5.07	.13	.063	.18	.11	1.03	660
	Sub-soil	6.93	.09	.034	.30	.11	0.85	2320
6	Top soil	1.46	.11	.051	.10	.11	0.80	660
	Sub-soil	4.20	.10	.037	.26	.08	1.32	1120
7	Top soil	2.86	.10	.053	.23	.13	0.93	780
	Sub-soil	4.96	.09	.041	.30	.11	0.96	2700
8	Top soil	3.14	.11	.058	.16	.11	0.97	600
	Sub-soil	4.57	.08	.039	.33	.10	0.85	1020
9	Top soil	3.07	.10	.065	.16	.16	1.40	680
	Sub-soil	5.63	.09	.045	.22	.14	0.91	180

Effect of Fertilizers Upon Tree Growth.—In studying the effects of the several combinations of plant foods upon the various plats, all points indicative of plant vigor or weakness should be noted. Perhaps the first that occurs to one, is the growth of the tree itself. This is especially important in the case of the peach which bears all its fruit upon wood of the previous year's growth. The producing power of the tree is in direct proportion to the amount of wood formed

*U. S. D. A. Bur. Chem. Bul. 107 Revised Ed.

each year, or stated in another way, the production is limited by the extent of wood growth. Other factors, however, sometimes have a bearing upon production as well as actual wood growth for, as we will show later, a poorly nourished tree will not produce fruit or fruit buds even to the limited capacity of its new wood.

TABLE VII. *Effect of Fertilizers Upon Growth of Bearing Trees.*

Treatment	Plat	Growth 1911 inches	Growth 1912 inches	Growth 1913 inches	Growth 1914 inches	4 year average inches
Nitrogen & Phosphoric Acid.......	1	11.65	30.5	13.88	8.4	16.1
Nitrogen & Potash................	2	9.98	26.5	12.5	8.9	14.47
Complete Fertilizer	3	10.3	28.	13.42	8.4	15.
Potash & Phos. Acid	5	6.89	16.5	4.66	4.6	8.16
Check	4	5.2	15.	4.23	4.7	7.28
Complete Fertilizer	6	9.88	28.3	11.74	9.7	14.4
Complete with Potash doubled	7	11.23	28.5	12.89	9.75	15.59
Complete with Potash tripled......	8	10.35	28.	12.22	9.8	15.
Lime	9	5 87	15.8	5.7	4.	7.84

Table VII shows the average length of the terminal growth each year, in the trees on the nine plats and also the average of four years' growth. Ten well distributed branches were measured from each of several typical trees of each block and the average secured. It will be noted that marked differences were apparent even at the end of the first season's growth (1911), the plats having nitrogen showing an increase over the others. In 1912 the growth was greater than in any other year, due to the entire destruction of the fruit crop by an unprecedented low temperature (–20° F.) on January 14th. of that year. The short growth of 1914 is explained by the large crop and very dry season. It is to be noted, however, that regardless of crop or season the nitrogen plats maintained a strong lead over

Fig. 1—Growth After Two Applications of Complete Fertilizer.

all others, an average for all nitrogen bearing plats for the four years showing a growth of 15.09 inches against an average of 7.76 inches for the non-nitrogen plats for the same period. Striking as the difference is, it does not indicate by any means the total difference in bearing capacity of the two sets of trees. A little reflection will show that the longer twigs will bear laterals in many cases, which are not included in the above measurements. After the first year the trees of the nitrogen blocks were larger than the others and because of their increased size and vigor produced many more branches than the weaker trees. (Figs. 1, 2 and 3.) At the end of the second year the total year's growth on two typical trees in the check and complete fertilizer blocks was measured. These trees were fair representatives of the nitrogen and non-nitrogen blocks, there being no apparent differences between the check plat and those receiving lime or acid phosphate and potash. The total length of growth on the fertilized tree was 774.5 feet and on the check tree 304.1 feet, or a difference of 470.4 feet. This means that for every foot of bearing surface on the check tree the fertilized tree carried over two and one-half feet of wood upon which fruit might be borne. This difference in size has been increasing so that the ratio would be much greater in favor of the nitrogen fertilized trees at the present time after four years of treatment.

Fig. 2—Growth After Two Applications of Nitrate of Soda and Potash.

Fig. 3—Growth After Two Years of no Fertilizer.

Influence of Plant Food Upon Foliage.

One often hears it stated that an orchard looks sick when its foliage is light colored and sparse and the remark is usually accompanied by the observation that "it needs a good dose of nitrogen." Both statements are undoubtedly true, for no other organs respond so quickly to favorable or unfavorable conditions as do the leaves. It is easy to understand this when we consider the functions of the foliage. Plant physiologists are pretty generally agreed that limited amounts of plant food may be taken up and utilized by cells of the roots, trunk or branches, but aside from these comparatively insignificant quantities the bulk of raw material absorbed by the roots is conveyed to the leaves where, under the action of chlorophyll, they are transformed into plant food. This process of food manufacture is the most delicately adjusted of all the life processes of the plant and hence the first to be thrown out of balance by disturbing circumstances. The diminution in amount of chlorophyll formed, as indicated by light color of the foliage, would have a marked deterrent effect upon the elaboration of food materials. The size of the leaves as well as the length of time they remained attached to the tree would obviously be in direct ratio to the amount of plant food they could manufacture, other things being equal. A dark colored, luxuriant foliage is proof apparent of the ability of a plant to manufacture large quantities of food, thereby promoting additional growth and productiveness. When we consider that the leaves perform the function of breathing, as well as manufacturing practically all the food used by the plant it is easy to see why anything which affects their proper development will have a correspondingly marked influence upon the whole plant. Conversely the leaves promptly reflect any change in the constitutional vigor of the plant.

To determine rather definitely the quantitative differences in the foliage of the different plants some careful measurements were made of the size of the leaves in 1911, 1913 and 1914. The area per leaf given in Table VIII was found by multiplying the length of a leaf by three-fifths of its width. It will be observed that the plant receiving nitrogen bore

leaves averaging around 4¼ square inches, the check and acid phosphate with potash plats averaged about 2¾ square inches, while the lime plat averaged a little better than 3¼ square inches. The trees receiving no nitrogen seemed to produce leaves slightly broader in proportion to their length than the nitrogen fed plats.

TABLE VIII. *Leaf Area of Trees Averaged From Three Year Records*

Treatment	Plat	Area per leaf (Sq. in.)	No. leaves per tree	Leaf area per tree (Sq. ft.)
Nitrogen and Acid Phosphate........	1	4.28	25,424	755.6
Nitrogen and Potash.......	2	4.26	24,808	734.4
Complete	3	4.06	23,208	654.3
Check	4	2.63	8,768	160.1
Acid Phosphate and Potash........	5	2.89	10,596	212.6
Complete	6	4.12	29,536	845.
Complete with Potash doubled..	7	4.39	32,368	986.7
Complete with Potash tripled.......	8	4.26	22,648	670.
Lime	9	3.26	14,172	320.8

Fig. 4—Nine Year Old Tree Fertilized Three Years with Acid Phosphate, Potash and Nitrate of Soda.

The most striking thing in connection with this table is the great numerical preponderance of leaves in the nitrogen blocks and the absolute lack of influence of potash and phos-

Fig. 5—Nine Year Old Trees Fertilized for Three Years With Acid Phosphate and Potash.

Fig. 6—Nine Year Old Tree Which Has Received no Fertilizer for Three Years.

phoric acid upon either number or size. It is obvious that a check tree such as is shown in Fig. 6, with less than 10,000 small leaves, cannot compete in growth and fruit production with such a tree as is shown in Fig. 4, having nearly

30,000 large, vigorous leaves, because of sheer inability to manufacture sufficient plant food even if the materials were available at the time.

The leaves were very dark green on the plats fed with nitrogen, while the pale yellowish green color of the other plats was plainly apparent. Inasmuch as the amount of green in the foliage is a guide to the amount of chlorophyll formed and as the chlorophyll is the active manufacturing agent in the production of plant food it is self evident that the trees in the nitrogen plats are vastly more efficient food factories than are the others. This efficiency is greatly augmented by the fact that these trees hold their foliage longer than those in the other plats.

The Production of Fruit Buds.—In some respects the number of fruit buds produced per year is a better index as to the value of a fertilizer than the amount of fruit. Many factors entirely foreign to the question of foods may affect the fruit, yet would have no bearing upon the formation of the buds. A spring frost might partially destroy the crop upon part of the plats, depredations by insects or ravages of disease might affect some portion, or other accidents, so common in nature, might alter the results. The production of fruit buds, however, represents a disposition toward fruitfulness in the tree, that is worthy of note.

Table IX. *Effect of Fertilizer Upon Set of Fruit Buds*

Treatment	Plat	1912	1913	1914	1915	Average
Nitrate & Acid Phosphate..	1	85%	100%	100%	37.5%	80.6%
Nitrate & Potash......	2	87%	100%	90%	25 %	75.5%
Complete	3	81%	100%	90%	25 %	74 %
Check	4	42%	60%	50%	80 %	58 %
Potash & Acid Phosphate..	5	49%	60%	50%	72.5%	57.9%
Complete	6	90%	94%	90%	32.5%	76.6%
Complete with Potash doubled	7	94%	92%	85%	30 %	75.2%
Complete with Potash tripled	8	92%	98%	85%	30 %	76.2%
Lime	9	40%	75%	70%	72.5%	64.4%

Table IX shows during the first three years a uniformly high percentage of fruit buds formed on the nitrogen fed plats and a correspondingly low percentage in plats 4, 5 and 9. By 100% set of buds we mean that practically all the new

growth is filled with double buds from base to tip as in the longer twigs in Fig. 7, while a 50% set would indicate that buds were found over only about one-half the twig and were single in many cases. (Fig. 7.)

The fact that the buds for 1915 showed a reversal of the order for the first three years is an interesting development from an abnormal season but in no way does it invalidate the data for the other years. During the summer of 1914 an unusually severe drought was experienced and this, coupled with the heavy crop matured by the nitrogen plats apparently depleted their moisture and probably their food supply to such an extent that they were unable to form fruit buds over the entire new growth. The non-nitrogen plats with the same supply of moisture as the others and with a smaller crop of fruit to mature were able to set a higher percentage of buds. The fact that their crop matured and was removed several days earlier than from the nitrogen rows, thus lessening the period of excessive food and moisture requirements, undoubtedly had a bearing upon the formation of buds. It is not to be understood that the trees receiving nitrogenous fertilizer have formed fewer buds than the others for such is not the case. They have not formed as many buds **per foot** of new growth as the other trees, but their greater volume of growth more than off-sets this so that the nitrogen trees have still produced more actual buds than the others. In former years when the nitrogen-fed blocks produced a greater percentage of buds than the plats 4, 5 and 9 the real difference in total number of buds was enormous, due to the fact that the former made five feet of

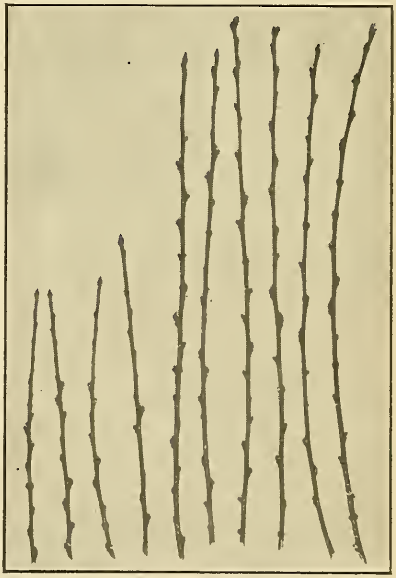

Fig. 7—Twigs from Nitrogen Plats on Right, Non-Nitrogen on Left. Note Set of Fruit Buds.

annual growth to only two feet in the case of the latter. In this connection it might be well to add that dying trees will put out a heavy bloom, while weak or poorly nourished trees will produce only a partial crop.

Fruit Production.

The most interesting data, to the practical grower at least, is that pertaining to the crop. In the present case the general health and vigor of the trees as indicated by wood growth and foliage were closely correlated with production. Table X gives a summary of the yields in 1911, 1913 and 1914—the 1912 crop having been destroyed by a freeze. The first year shows a varied yield with no uniform correlation of fertilizer applications and production, but this should be expected as the crop had been largely determined the year previous when the fruit buds were formed. The last two years, however, show the increased yields from the more vigorous plats due to the presence of nitrogen.

Table X. *Effect of Fertilizer Upon Yield of Fruit Per Tree*

Treatment	Plat	1911	1913	1914*	Average	Average 1913-1914
		Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
Nitrogen & Acid Phosphate..	1	41.88	74.08	93.9	69.95	83.99
Nitrogen & Potash..........	2	47.3	81.29	87.2	71.93	84.24
Complete	3	48.49	64.79	92.9	72.06	78.84
Check	4	46.81	51.32	50.3	49.48	50.81
Potash & Acid Phosphate..	5	45.69	46.86	34.7	42.42	40.78
Complete	6	51.63	90.76	104.5	82.29	97.63
Complete with Potash doubled	7	52.38	99.67	94.2	82.09	96.93
Complete with Potash tripled	8	49.09	107.97	90.7	82.59	99.33
Lime	9	44.13	58.53	79.8	60.82	69.16

*Waddell crop—Carman not averaged in since part of record is lacking.

The fact that Plat No. 5 yielded less than the check may have some significance although the amount of potash applied was not excessive for a bearing tree. It has already been shown by Corbett's work (page 10) that potash may be injurious to peach trees and our own work with younger trees (page 28) is in accordance with Corbett's results. The fact that in wood growth, leaf area, and set of fruit buds this

plat was not inferior to the check plat leads one to the belief that the present instance is probably a chance fluctuation and should be given little weight.

WADDELL

TABLE XI. *Effect of Fertilizer Upon Date of Ripening in* 1913

Treatment	Plat	% Picked July 28	% Picked July 30	% Picked Aug. 2	% Picked Aug. 4
Nitrogen & Acid Phosphate..........	1	21%	65.7%	13%	.3%
Nitrogen & Potash....................	2	32%	52 %	16%	
Complete............................	3	32%	41 %	26%	
Check	4	96%	4 %		
Acid Phosphate	5	84%	15 %	1%	
Complete	6	63%	32 %	5%	
Complete with Potash doubled..	7	48%	39 %	13%	
Complete with Potash tripled........	8	54%	41 %	4%	
Lime	9	76%	22 %	2%	

CARMAN

Treatment	Plat	% Picked July 31	% Picked Aug. 2	% Picked Aug. 4	% Picked Aug. 5
Nitrogen & Acid Phosphate..........	1		45.4%	54.5%	.1%
Nitrogen & Potash	2		56 %	43%	.1%
Complete	3		27 %	73%	
Check	4		95 %	5%	
Potash & Acid Phosphate............	5		87 %	13%	
Complete..............................	6		23 %	77%	
Complete with Potash doubled.... ..	7		54 %	46%	
Complete with Potash tripled........	8		40 %	59.8%	.2%
Lime	9	13%	82 %	5%	

TABLE XII. *Effect of Fertilizer Upon Date of Ripening in* 1914.

WADDELL

Treatment	Plat	% Picked Aug. 4	% Picked Aug.6	% Picked Aug. 8
Nitrogen & Acid Phosphate..........	1	24.2%		75.8%
Nitrogen & Potash	2	32.9%		67.1%
Complete..............................	3	30.3%		69.7%
Check	4	97.2%	2.8%	
Potash & Acid Phosphate	5	87.4%	12.6%	
Complete.....................	6	40.1%		59.9%
Complete with Potash doubled.......	7	60.3%		39.7%
Complete with Potash tripled........	8	57.2%		48.8%
Lime	9	75%	25 %	

CARMAN

Treatment	Plat	% Picked Aug. 4	% Picked Aug. 6	% Picked Aug. 7	
Nitrogen & Acid Phosphate	1	60.6%		39.7%	
Nitrogen & Potash....................	2	41.4%		58.6%	
Complete..............................	3	35.1%		64.9%	
Check	4				
Potash & Acid Phosphate...........	5				
Complete..................	6	34.2%		65.8%	
Complete with Potash doubled.......	7	53%		47%	
Complete with Potash tripled.... ...	8	40%		60%	
Lime	9				

Maturity of Fruit.—The effect of the nitrogenous fertilizer upon the time of maturity was in accordance with current opinion. In short, whenever nitrogen was added, the ripening of the fruit was delayed several days. The tables (XI and XII) do not quite indicate the full extent of this difference, for in maturity for each year plats 4, 5 and 9 were somewhat over-ripe at the first picking and for best commercial returns should have been picked two or three days earlier. In the case of the Carman variety in 1914, the peaches upon these plats showed a marked inclination to produce split pits and ripen prematurely. On this account the fruit from them was practically all gathered ten days or two weeks before the other plats matured and the record of their actual yield was not secured. **By a judicious application of nitrate of soda the ripening date of early peaches may be delayed a week and mid-season varieties ten days.** This is a matter of considerable moment as often a delay of a week on Carman would clear the market of the last of the Georgia Elbertas and the price would be much improved.

Color of Fruit.—It is practically impossible to measure the color factor, but in this case results are so plainly apparent that there is no need to resort to fine distinctions. The fruit from the plats to which nitrogen had been added carried at picking time a good blush overspreading a creamy or greenish ground color, while the fruit from the non-nitrogen blocks was colored nearly a solid red. When interpreting these results two modifying factors must be kept in mind. First, the fruit from the latter blocks was more

nearly mature when harvested than from the former; and secondly, the foliage on the nitrogen-fed trees was heavier than upon the others, thereby cutting down the amount of sunlight reaching the fruit and presumably lessening the intensity of the color. In connection with maturity it was observed in some instances that when fruit from the nitrogen rows was allowed to hang upon the trees until it reached the same stage of ripeness as was attained by plats 4, 5, and 9 at picking time, the color of the nitrogen-fed fruit was greatly intensified but was still under the color of the other blocks. As a matter of fact it happened, at times, that the fruit from the non-nitrogen rows colored so deep and dark that it was not as attractive as the lighter blushed fruit from the nitrogen plats.

The writer believes that the difference in color observed between the plats may be entirely accounted for upon the grounds of maturity and amount of sunlight which reached the fruit. That either potash or phosphoric acid directly affected the color seems very improbable for all the plats to which nitrogen was applied colored alike, regardless of whatever else was applied. In the same way the check plat, the phosphoric acid and potash plat, and the lime plat colored exactly alike. Plats 6, 7, and 8 received single, double and triple applications of potash, respectively, with absolutely no effect upon color of fruit, a fact which indicated the worthlessness of this material as a coloring agent. "Potash paints the fruit" is an old and favorite precept but like the superstitious "planting by the moon" should be regarded only as a curious relic of former practice. The earlier maturity of fruit and the sparse foliage is undoubtedly responsible for the higher color of the fruit in the non-nitrogen blocks.

The foregoing statements bearing upon color find liberal support in the recent work of other investigators. Hedrick* finds no indication, after extended trials, that potash will alter the color of apples. McCue,† in discussing a seven-year peach fertilizer experiment, states, "Color is largely a matter of sunshine. Increased color comes with diminished leaf surface." Chandler‡ reports, "While

*Hedrick, U. P. Agr'l. Exp't. Sta., Geneva, N. Y. Bul. 339.
†McCue, C. A.—Report Peninsula Horticultural Society for 1915.
‡Chandler, W. H.—American Pomological Society Report, 1911, Page 231-234.

potassium and phosphorus apparently have no appreciable effect upon the color when applied to Ozark soils, it is well known that an application of even a fairly small amount of nitrate greatly affects the color of peaches—but detrimentally, and large quantities may so injure the color that the peaches may be of little value." In this connection Chandler found that an application of nitrate was necessary for best results but that when applied late (during June) it did not injure the color as did the earlier applications but was as beneficial in all other respects.

Grade of Peaches.—Four grades were made of the peaches each year, which were designated according to size as Extra Fancy, Fancy, Choice, and No. 2-with-culls. The No. 2-with-culls grade was not worthless but included all peaches too small to pack 3 - 2 diamond pack in the Georgia carrier. The differences in size indicated in Table XIII were not striking, particularly in 1914. This was due to the fact that the fruit was thinned that year and all plats were able to develop fair size. The tendency was slightly to increase the size of fruit by the use of nitrogen and potash as indicated by the average of all the nitrogen plats showing 30.4% of all fruit in the fancy and extra fancy grades against an average of 28.1% in non-nitrogen plats, and an average of potash plats showing 31.8% against 25.2% for plats receiving no potash. The data for the first four years as regards size of fruit is not very clear cut and should be considered as merely suggestive.

TABLE XIII. *Effect of Fertilizer Upon Grades of Peaches*

Percent of 1913 and 1914 Crops in the Packing House Grades

Treatment	Plat	Culls No. 2	Choice	Fancy	Extra Fancy
Nitrogen & Acid Phosphate........	1	9 %	70.2%	20.7%	.1 %
Nitrogen & Potash...............	2	3.8	72.9	23	.3
Complete....................	3	4.2	64	31.1	.7
Check	4	5.5	70.8	23.7	
Potash & Acid Phosphate.........	5	4.2	66.3	29.5	
Complete..............................	6	1.8	71.3	25.4	1.5
Complete with Potash doubled...	7	2.1	59.2	38.1	.6
Complete with Potash tripled.....	8	2.2	56.8	39.8	1.2
Lime	9	7.1	61.7	29.6	1.6

Yields and Income.—In order to gain some idea of the influence of the fertilizers upon the financial returns of an orchard, the yields of 1913 and 1914 were figured upon the acre basis, using 134 trees per acre (Table XIV). The crops of these years had been divided into four grades, such as were used in the packing house, Extra Fancy, Fancy, Choice, and No. 2-with-culls. The last grade was really two grades in one and was usually divided at the packing house but in gathering our data no attempt was made to separate them. The two years happened to be ones of very high and very low prices so that the prices used here (Table XV), which are averaged from the two years, would be about normal. The No. 2 and cull grade are figured at 40 cents per Delaware basket, the Choice at $1.35 a carrier, the Fancy at $2.00 a carrier, and the Extra Fancy at $2.50 a carrier. In reckoning the yields a net weight of 22 pounds was allowed for a Delaware basket and 39 pounds for a carrier.

Table XIV. *Yields Per Acre*

Treatment	Plat	Total Yield Lbs.	Baskets Culls & No. 2	Carriers Choice	Carriers Fancy	Carriers Extra Fancy
Nitrogen & Acid Phosphate....	1	11255	46	202.6	59.7	.3
Nitrogen & Potash.......... ..	2	11288	14.9	211	66.5	.8
Complete	3	10565	20.2	173.6	84.2	1.9
Check............................	4	6809	17	123.5	41.4	
Potash & Acid Phosphate......	5	5465	10.4	92.9	41.3	
Complete..............	6	13082	10.7	230.1	85.2	5
Complete with Potash Doubled	7	12989	12.4	197.1	126.9	2
Complete with Potash tripled	8	13310	13.3	193.8	135.8	4.1
Lime...................	9	9267	29.9	146.3	70.3	3.8

Table XV. *Income Per Acre*

Treatment	Plat	Culls & No. 2	Choice	Fancy	Extra Fancy	Total Gross
Nitrogen & Acid Phosphate....	1	$18.40	$253.51	$119.40	$ .75	$392.06
Nitrogen & Potash.......... ...	2	5.96	284.85	121.00	2.00	413.81
Complete	3	8.08	234.36	168.40	4.75	415.59
Check............................	4	6.80	166.73	82.80		256.33
Potash & Acid Phosphate......	5	4.16	125.42	82.60		212.18
Complete..........	6	4.28	322.79	170.40	12.50	509.97
Complete with Potash Doubled	7	4.96	266.09	256.80	5.00	532.85
Complete with Potash Tripled	8	5.32	261.63	271.60	10.25	548.80
Lime..........................	9	11.96	197.51	140.60	7.70	257.77

For some reason not yet apparent plats 6, 7, 8, and 9 seem to produce better than the series 1, 2, 3, and 5. The land is as uniform a piece as one could well select and the chemical analyses show no appreciable differences between plats. As mentioned before, plats 1 and 2 are a little more subject to frosts than the others but this does not explain the difference in production between plats 3 and 6 which received identical treatment. In any event it is very plain that nitrogen is the only element producing a decided increase in returns.

The Influence of Lime.—The behavior of the lime plat is difficult to explain. In twig growth, color and grade of fruit, and time of maturity, it differs in no way from plats 4 and 5 (check and acid phosphate with potash) yet in leaf area, fruit bud and fruit production it slightly exceeds these two plats but falls well below the nitrogen blocks. Most certainly it seems that it is not a limiting factor in fruit production, or the high yields from plats 6, 7, and 8 would not have been secured. The data is much too limited to warrant any deductions other than that the results are largely negative.

Cherry Run Experiment.

This test was started in the spring of 1911 in a young peach orchard managed by M. W. Fulton, about one-half mile from the Baltimore & Ohio depot at Cherry Run, W. Va. The trees were planted the same season the experiment was begun so that we have had an excellent opportunity to study the effects of the treatment from the beginning of an orchard up to bearing age.

Plan of Experiment.—Only five plats were included in this test. Each plat is made up of a single row of Carman peaches containing twenty trees. A weak point in the experiment from the standpoint of future work is the lack of guard rows between the plats to prevent interfeeding. Unquestionably there has been no danger from this cause up to the present time as the trees have been too small to reach over into the next row, eighteen feet away. This trouble is sure to appear, however, and probably will necessitate abandoning the test in a few years. The materials and amounts used are indicated in Table XVI.

The fertilizers were applied by hand each year and scat-

tered about the trees under the spread of the limbs. The dates of application were May 19, 1911; June 8, 1912; June 3, 1913, and May 20, 1914.

TABLE XVI. *Arrangement of Plats at Cherry Run*

Plat	Treatment	Lbs. Per Tree 1, 2, & 3 Yrs.	Lbs. Per Tree 4th Yr.
PLAT 1	Nitrate of Soda.........	¾ lb.	1 lb.
	Acid Phosphate 16%...	1¼	1¾
PLAT 2	Nitrate of Soda.........	¾	1
	Muriate of Potash......	½	¾
PLAT 3	Nitrate of Soda........	¾	1
	Acid Phosphate 16%...	1¼	1¾
	Muriate of Potash......	½	¾
PLAT 4	Acid Phosphate 16%...	1¼	1¾
	Muriate of Potash......	½	¾
PLAT 5	Check....................		

Character of Soil.—The soil is a yellow shale type similar to that in the Sleepy Creek experiment but rather more fertile. The soil analyses in Table XVII, taken from samples collected in the third year of the test, show a decidedly higher plant food content than the Sleepy Creek soils. (Table VI.) The analyses in both experiments were made by Professor B. H. Hite and as the same methods (official method of American Association of Agricultural Chemists) were used in each case the results indicate a fair comparison of the two soils.

TABLE XVII. *Analyses of Cherry Run Soils*

Plat	Soil	Moisture	P_2O_5	N.	K_2O	CaO	Humus	Acidity (CaO) Lbs. Per Acre
1	Top soil.....	5.84	.11	.127	.24	.13	1.64	2920
	Sub soil	6.09	.13	.091	.32	.18	1.12	3300
2	Top soil.....	4.21	.14	.135	.34	.09	1.80	3040
	Sub soil.....	9.06	.11	.092	.32	.10	1.40	3780
3	Top soil.....	2.44	.11	.138	.24	.22	1.63	2760
	Sub soil.....	5.23	.14	.088	.25	.20	1.25	3720
4	Top soil.....	6.23	.12	.122	.30	.17	1.67	3240
	Sub soil.....	10.23	.14	.088	.26	.17	1.20	3600
5	Top soil.....	5.43	.12	.144	.26	.20	1.78	3800
	Sub soil.....	2.54	.11	.106	.30	.21	1.35	4060

Growth of Trees.—Curiously enough no appreciable differences due to any of the fertilizers were detected the first year. Doubtless the trees were not large enough or thorough-

Fig. 8—Carman Peach Three Years Old Fertilized With Acid Phosphate, Potash and Nitrate of Soda.

ly enough established in the soil to be able to absorb and use a great deal of plant food this year. The soil, while not rich, was evidently able to supply the needs of the tree so abund-

Fig. 9—Carman Peach Three Years Old Fertilized With Acid Phosphate and Potash.

antly that not even the readily soluble nitrate of soda was utilized.

After the first year the most striking results were apparent. Whenever nitrogen was used it produced luxuriant growth and dense, dark green foliage. Neither potash nor phosphoric acid in combination with nitrogen produced any apparent results as there was no difference in appearance between plats 1, 2 and 3. Plat 4 has constantly fallen below the check Plat 5 each year after the first and tends to verify the earlier work by Corbett in which the malnutritive effects of the presence of potash were observed. The difference between plats 4 and 5 is brought out in Figs. 9 and 10. Both are much inferior in size and vigor to plats 1, 2, and 3 (Fig. 8), but the fact that there is an apparent loss in vitality due probably to potash is interesting and suggestive.

TABLE XVIII. *Growth of Young Trees*

Plat	Treatment	1911 Inches	1912 Inches	1913 Inches	1914 Inches	Average Inches
1	Nitrogen & Acid Phosphate........	No.	54	53.3	43.3	50.2
2	Nitrogen and Potash...............	effect	36	51.5	43.2	43.6
3	Complete	of	46	51.5	44.3	47.3
4	Potash and Acid Phosphate.......	Fertili-zers	24	32.5	32.5	29.7
5	Check	apparent	30	39.9	33.9	34.6

Fig. 10—Carman Peach Three Years Old Which Has Received no Fertilizer.

Another method of measuring tree vigor is found in the increase in diameter of the trunk. The trees were not calipered at the beginning of the experiment but all were similar in size. The measurements taken in 1914 show an average gain of 32% for the nitrogen plats over the check, while the loss of 26% for Plat 4 is another indication of the inhibiting effect of potash mentioned before. The fact that Plat 2 is slightly inferior to plats 1 and 3 in both length of growth and diameter of trunk points to injury by potash which in Plat 3 is largely overcome by the addition of acid phosphate. To draw final conclusions, however, from such limited data without further study would be unwise.

TABLE XIX. *Diameter of Trunks of Young Trees*

Plat	Treatment	Diameter 1914	Gain over Check
1	Nitrogen and Acid Phosphate..........	2.5 in	36%
2	Nitrogen and Potash..................	2.37	26%
3	Complete	2.52	34%
4	Potash and Acid Phosphate...........	1.37	—26%
5	Check	1.87	0

Effects of Fertilizer Upon Foliage.—Nitrogen plats produced foliage distinctly larger, darker and denser than did the check, and acid phosphate and potash plats. Table XX gives interesting figures relative to the leaf area of three-year-old trees in 1913. No counts were made of the trees in plats 1 and 2 as they showed no distinct differences from Plat 3, although subsequent measurements of growth indicated that Plat 2 would have probably been somewhat under the other two. Comparison with Table VIII shows the leaves of the older trees in the Sleepy Creek test to be considerably smaller than those of the younger trees at Cherry Run.

TABLE XX. *Influence of Fertilizer Upon Leaf Area in* 1913

Plat	Treatment	Leaves per tree	Area per leaf	Area per tree
3	Complete	4372	7.3 sq. in.	221.6 sq. ft.
4	Potash & Acid Phosphate	1572	4.42	48.2
5	Check	2220	4.5	69.3

Fruit Buds and Fruit.—The fourth season a small crop of fruit can reasonably be expected from trees in this state and those in this experiment were no exception to the rule.

All five plats showed a fair number of fruit buds formed but only a small quantity of fruit matured—in no sense a commercial crop. It should be noted that while plats 4 and 5 showed a very good per cent of fruit buds formed in 1914 the trees were so small in size that they could carry only a vestige of a crop.

TABLE XXI. *Fruit Buds and Fruit*

Plat	Treatment	Fruit 1914	Bud 1915	Fruit per Plat 1914
1	Nitrogen and Acid Phosphate.....	89%	95%	30 lbs. 1 oz.
2	Nitrogen and Potash...............	87%	95%	5 lbs. 12 oz.
3	Complete	93%	95%	49 lbs. 6 oz.
4	Potash and Acid Phosphate.......	81%	97%	1 peach
5	Check	81%	97%	3 lbs. 8 oz.

GENERAL CONSIDERATION OF RESULTS.

A survey of the three experiments leads to several conclusions, foremost of which is that nitrogen strongly stimulates vegetative growth. This knowledge is neither new nor startling but that this stimulation is necessary or would be beneficial in the case of the peach is comparatively new doctrine. Lecturers, writers and growers have in common been imbued with the idea that to manure or highly fertilize the peach with nitrogenous compounds would be to jeopardize either crop or orchard, or both. James Fitz,* in his Southern Apple and Peach Culturist, reflects more or less accurately the general impression of his time. He states, "A middling fertility should * * * be preferred, as producing vigorous and healthy trees, bountiful crops, and fruit of fine size and quality." The writer has yet to see a peach orchard suffering from too rich a soil. There are undoubtedly orchards that will not respond to fertilizers of any kind because of the natural fertility of the soil, but upon the mountains and hills of West Virginia such abundant fertility is exceptional.

We know that the peach is a high nitrogen feeder yet few realize the amount of nitrates that may be applied to the peach orchard, not only without injury but with profit. In an account of the seven-year peach fertilizer experiment at Newark, Delaware, McCue† states: "In Plat 23 * * * *

*Fitz, James, Southern Apple & Peach Culturist—Page 242, Richmond, Va. 1872.
†McCue, C. A.—Peninsula Horticultural Society Report—1915.

we have a case where about 1,000 pounds per acre per year of nitrate of soda has been applied. Based upon previous conceptions of the effect of nitrogen upon peaches, we would have expected but little if any fruit and an enormous growth of wood. We secured the wood: but incidently the trees have averaged nearly nine baskets of fruit per year for the past three years. In 1914 they actually picked 19 baskets of peaches per tree. Of course we had partially balanced the fertilizer by adding 50 lbs. of potash and 50 lbs. of phosphoric acid. I cannot tell what would have happened if the potash and phosphoric acid had not been added but I am inclined to believe that we would still have had a good crop."

TABLE XXII *Yield of Peaches at Delaware Experiment Station*

Orchard 7 Years Old. Fertilizers Applied Yearly.
Yield in Baskets Per Acre

Plat	Treatment	1912	1913	1914	Total
1	K	348.0	236.0	180.4	764.4
2	Check	432.8	96.5	313.2	842.5
3	K (2)	708.6	333.5	523.8	1565.9
4	P	410.2	82.7	469.8	962.7
5	Check	199.5	78.5	225.7	503.7
6	P (2)	53.3	000.*	771.2	824.5
7	Check	18.4	43.2	559.4	622
8	K. P.	122.3	349	368.3	839.6
9	N.	171.8	179.2	1859.8	2210.8
10	Check	244.2	80.9	703.1	1028.2
11	N. K.	471.2	135.6	2144.9	275[illegible].7
12	N. P.	269.8	.2	1211.8	1481.8
13	K (2) P..........	7.9	206.5	710.6	925.0
14	K. N. P............	18.3	231.4	740.9	990.6
15	K. N. (2) P.......	206.0	458.9	1348.9	2013.8
16	N. (2) K..........	526.0	331.6	2095.2	2952.8
17	N. (2) P..........	556.5	106.8	1782.0	2445.3
18	Check	381.8	1.2	432.0	815.0
19	N. K. (2) P......	57.6	53.0	137.2	247.8
20	Check	6.8	34.8	252.7	294.3
21	N. K. P. (2)......	80.3	520.1	977.4	1577.8
22	N. K. (3) P......	324.3	478.8	1226.9	2030.0
23	N. (3) K. P......	551.1	183.6	1971.4	2706.1
24	N. K. P. (3)....	244.4	21.6	1671.4	1937.4

*Killed by spring frost.

A survey of the yields from the various plats in McCue's experiment shown in the accompanying table, convinces us that he is justified in the deduction, the more especially since it is accompanied by the following illuminating explanation:

"If we examine those plats that totaled 1,500 baskets or

over for the three years we find that with one exception they had received annual applications of nitrate of soda. The exception is Block 3, where 200 lbs. of muriate of potash has been applied annually per acre. These trees, however, are declining and are not in good condition to go on producing crops. The blocks where nitrogen was used are all in good condition and, barring yellows or little-peach, they should go on producing large crops for many years. The increase in fruit production has a direct bearing to the increase of nitrogen applied as a fertilizer."

He further states: "The old belief that potash was the most important plant food element for peaches has not been borne out by this experiment. Potash is important but it does not have as large an influence in fruit bud formation as nitrogen." The only essential point of difference between the Delaware results and the West Virginia results reported in this bulletin is in the influence of potash. It seems clear that the thin shale soils of this state will not respond to potash, but the more sandy soils of Delaware may in some cases, need a small amount of this material to secure maximum production. Unquestionably West Virginia peach growers should not buy potash for their orchards without having first experimented with it on a small plat to determine whether by any chance their soil is too deficient in this plant food to afford satisfactory yields.

The benefits of acid phosphate are also of a very questionable nature. In none of the experiments that have come to the writer's attention has there been any clearly defined gain due to the use of phosphorus as a plant food for the peach. To offer a possible explanation of this we have only to remember that the peach uses comparatively small quantities of this material in the production of wood, foliage and fruit.

Recommendations.

The commercial peach industry of West Virginia is at present confined almost wholly to a few counties in the Eastern Panhandle and, broadly speaking, includes only two general types of soil—shale and chert. In the writer's experience the chert lands when reasonably well

cared for do noc require artificial fertilization. They are, however, of comparatively recent development and in time may become exhausted to the point where feeding will be necessary. The shale lands upon which most of the commercial orchards stand present a serious problem. The writer is convinced that thousands of dollars have been thrown away by orchardists on that type of soil through misdirected applications of fertilizers running high in phosphoric acid and potash. From the result of our four years of experimentation and from reports from neighboring states we unhesitatingly recommend for bearing trees the application of 200 to 250 lbs. of nitrate of soda (or equivalent amount of nitrogen in some readily available form) per acre for shale soil. For young trees we would suggest little or no fertilizer the first year but after that one-half pound of nitrate of soda per tree until its fourth year, when the application may be doubled. We believe that the same treatment will be effective on other poor soils throughout the state although this has not yet been definitely determined.

The Use of Cover Crops.—The practical point at once arising is, can the expensive nitrogen be supplied as effectively and more cheaply by the use of leguminous cover crops? It seems reasonable to believe this to be the case. Crimson clover, winter vetch, cowpeas, soy beans, red clover, and other leguminous crops may be easily grown upon such soils, and all collect nitrogen from the air in considerable quantities. A continuation of these experiments incorporating a test of leguminous cover crops and the effect of heavier applications of nitrogen is planned for the future.

SUMMARY.

1. Because of the small amount of published data bearing upon peach orchard fertilization it is deemed advisable to publish this preliminary report covering four years' work.

2. Several experiment stations have attempted to determine the needs of the peach by analyses of its tissue. These show that the peach is a heavier feeder than other fruits and that it uses large amounts of nitrogen and potash and very small amounts of phosphorus.

3. Work by Wheeler and others indicates the possibility of a conservation of the potash supply in the soil due to the use of sodium. When nitrate of soda is applied it may, in addition to supplying nitrogen, substitute, in part at least, its sodium for potash that might otherwise have been used.

4. In the past quarter century several plat experiments have been attempted but accidents were so numerous that the results can be considered merely as suggestive. In most cases the best results were secured through the application of some form of nitrogen.

5. Early work in West Virginia gave better results from the use of complete fertilizers than from incomplete fertilizers. Of the several single elements of plant food used, nitrogen gave the best results. Potash diminished development and in some cases killed the trees, while phosphoric acid in no way influenced either vigor or productiveness.

6. At Sleepy Creek, W. Va., an experiment with bearing trees has been in progress four years on a shale loam soil low in fertility, twenty trees of Carman and Waddell peaches constituting a plat.

7. The yearly growth of the trees treated with nitrate of soda has been double that of plats receiving no nitrogen.

8. At the end of the second year the bearing surface of the nitrogen fertilized trees was 2½ times that of the non-nitrogen fed block. At the end of the fourth year the difference was much greater.

9. The leaves of the nitrogen blocks were healthier than the others, larger in size, about 2½ times as numerous, and made up nearly four times greater area per tree.

10. The nitrogen plats have set an average of 76 per cent fruit buds each year against 60 per cent in the non-nitrogen plats.

11. The yield of fruit was very nearly doubled by the use of nitrogen.

12. Nitrogen delayed maturity several days.

13. The fruit was not as highly colored in the nitrogen blocks as in the others. The high color of the non-nitrogen rows was not due to the influence of potash or any other fertilizer but rather to the extra sunshine that reached it through the sparse and sickly foliage.

14. The difference in size of fruit was not great but nitrogen and potash in combination produced a slight increase.

15. The average gross income per acre per year from all the nitrogen plats was $468.85 and from the non-nitrogen plats was $275.43.

16. The influence of lime could not be definitely determined and must be regarded as largely negative although the production was somewhat increased.

17. An experiment on young trees at Cherry Run on the same kind of soil was carried on in a manner similar to the Sleepy Creek test.

18. No appreciable influence of any fertilizer could be detected the first year, due probably to the inability of the young trees to take up and assimilate large quantities of plant food.

19. After the first year nitrogen produced a strong growth of wood and foliage while potash apparently weakened the vigor of the tree.

20. Only a small crop of fruit was produced the fourth year but it was practically all from the nitrogen-fed trees.

21. The theory that heavy fertilizing with nitrogen is injurious to the peach is shattered by these experiments, as is also the former conception of the value of potash.

22. Recommendations for shale and other soils low in fertility are 200 to 250 lbs. of nitrate of soda per acre for bearing trees and ½ lb. per tree for young trees after the first year. The fourth year this amount may be doubled.

23. It is thought probable that the necessary nitrogen may be advantageously supplied by means of leguminous cover crops but this point has not yet been clearly demonstrated.